Available online at http://www.ijabbr.com

International journal of Advanced Biological and Biomedical Research

Volume 1, Issue 9, 2013: 993-998

Comparison of absorbed fraction of Gamma and Beta rays of I-124 and I-131radio-isotopes in thyroid gland with Monte Carlo Simulation

Mohammad Mirzaei [*1], Hossein Mirshekarpour [2]

[1] Department of Physics, Faculty of Shahid Chamran of Kerman, Technical and Vocational University, Kerman, Iran

[2] Department of Nuclear Medicine, Kerman Medical science University, Kerman, Iran

ABSTRACT

I^{131} is a famous radio-iodine isotope in use for diagnosis and treatment of hyper functioning and cancerous thyroid gland. It is a nuclear reactor product; however nuclear reactor may be unavailable in some areas. Replacement by I-124 may be possible, another iodine isotope producible by cyclotron; a system more available than reactor. Here absorbed fraction of Gamma and Beta rays of I-124 throughout thyroid and neck soft tissues are measured and compared with I-131. Employing I-124 as substitute for I-131 is also discussed. First of all, the input file for MCNPX code has been prepared to calculate F6 and F8 tallies. Then the code has been run for F6 and F8 tallies for variation of lobe volume from 1 to 25 milliliters. From the output file of tally F6, the gamma absorbed fraction in thyroid and neck tissue for the volume lobe variation from 1 ml to 25 ml have been derived. As well as, form the output of F8 tally the absorbed energy of beta in thyroid and soft tissue of neck is obtained and then absorbed fraction of beta has been calculated. Finding indicated that for constant activity in thyroid and soft tissue the gamma absorbed fraction for I-124 is less than I-131. For the same situation, the beta absorbed fraction of I-124 in thyroid is less than I-131 and in soft tissue is more than I-131. If I-131 is non-available it may be replaced by I-124for treatment of cancerous or hyper functional gland.

Key words: Monte Carlo Method, Thyroids cancer, Absorbed fraction, Hyper- functioning thyroid gland, Radio-iodine isotope

INTRODUCTION

Iodin-131 isotope is used in treatment of hyper functioning thyroid gland and differentiated thyroid cancers (Vini and Harmer.2000),(Traino et al.2000) .Investigations reveal I-131 as better choice in long term (AllahAbadia et al.2001),(. Cooper et al.2006).While an isotope is administered to patient, absorbed radiation dose may be a limitation factor for treatment because normal tissues also can be damaged (Cember and Johnson.2009) beside tumoural cells. Therefore selected administration dose should have

Corresponding Author E-mail: m.mirzaei@tvu.ac.ir

maximal therapeutics effects and minimal side effects. MIRD Committee has considered thyroid lobes spherical in shape each about 10 grams in mass. Considering these parameters, special absorbed fraction of beta and gamma rays is calculated throughout thyroid gland and other organs and results are prepared and presented as tables for estimation of best dose (Snyder et al.1969). Physician should first measure thyroid gland mass and multiply by special absorbed fraction to obtain absorbed fraction and then do other calculations to measure I-131 dose for administration. Despite MIRD considerations, anatomical evaluation and thyroid imaging show that thyroid lobes aren't spherical but they are olive- shaped. In this study we assumed olive - shaped thyroid lobes and calculations were performed separately for different volumes of thyroid to obtain more accurate results. Absorbed fraction of I-131 and I-124 are measured and compared to evaluate possibility of I-131 replacements by I-124.

MATERIALS AND METHODS

In this study MCNPX code is used for calculations which work on the basis of Monte Carlo Method and is a powerful software which stimulates radiation traveling (Waters .2002).First of all, beta and gamma spectrums of I-131 and I-124 were extracted from isotope project website in united states (Firestone and Ekström.1999).Using these spectrums, MCNPX code was prepared for F6 and F8 tallies and run for thyroid volumes from 1 to 25mL. Mathematical information of human body phantom are obtained from MIRD phamphled5, of course thyroid lobes shape are changed to olive which is similar to human native anatomy and would result in more accuracy. Large diameter of olive is considered twice than small diameters. Subsequently beta and gamma absorbed doses throughout different organs was extracted from output data files and recorded for measuring absorbed fraction.

Within an organ with defined mass and gamma absorbed dose, absorbed gamma energy can be calculated as below:

Absorbed energy in target organ =mass of organ × absorbed dose. Equation (1)

Absorbed fraction is defined as:

Absorbed fraction (φ) = absorbed energy in target organ/ energy originating from source. Equation (2)

Using data and described equations (1&2) beta and gamma fraction dose within thyroid and neck soft tissue are measured and mentioned in table (1).

Origin software was applied to processing table (1) data and recording graphs for gamma and beta absorbed fraction (figure 1&2).

RESULTS AND DISCUSSION

Absorbed fraction for gamma and beta rays of I-131 and I-124 according to thyroid volume range are mentioned in table(1).

Table 1: Gamma and Beta Absorbed fraction for I131 and I124 in thyroid and neck tissue

Thyroid Volume (mL)	Beta Absorbed Fraction				Gamma Absorbed Fraction			
	I-124		I-131		I-124		I-131	
	Thyroid	Tissue	Thyroid	Tissue	Thyroid	Tissue	Thyroid	Tissue
1	7.49E-1	2.51E-1	49.9E-1	5.10E-2	9.69E-3	9.04E-2	1.50E-2	1.41E-1
2	7.98E-1	2.02E-1	59.9E-1	4.06E-2	1.22E-2	8.99E-2	1.88E-2	1.41E-1
3	8.23E-1	1.77E-1	65.9E-1	3.54E-2	1.40E-2	8.94E-2	2.16E-2	1.40E-1
4	8.39E-1	1.61E-1	9.68E-1	3.22E-2	1.54E-2	8.90E-2	2.37E-2	1.39E-1
5	8.50E-1	1.50E-1	9.70E-1	3.00E-2	1.65E-2	8.86E-2	2.56E-2	1.39E-1
6	8.59E-1	1.41E-1	9.72E-1	2.82E-2	1.76E-2	8.81E-2	2.71E-2	1.38E-1
7	8.66E-1	1.35E-1	9.73E-1	2.69E-2	1.85E-2	8.77E-2	2.86E-2	1.38E-1
8	8.72E-1	1.29E-1	9.74E-1	2.56E-2	1.94E-2	8.73E-2	3.00E-2	1.37E-1
9	8.77E-1	1.24E-1	9.75E-1	2.47E-2	2.01E-2	8.69E-2	3.11E-2	1.36E-1
10	8.81E-1	1.20E-1	9.76E-1	2.38E-2	2.08E-2	8.65E-2	3.23E-2	1.36E-1
11	8.84E-1	1.16E-1	9.77E-1	2.31E-2	2.14E-2	8.61E-2	3.33E-2	1.36E-1
12	8.88E-1	1.13E-1	9.78E-1	2.24E-2	2.21E-2	8.57E-2	3.43E-2	1.36E-1
13	8.91E-1	1.10E-1	9.78E-1	2.18E-2	2.26E-2	8.54E-2	3.52E-2	1.34E-1
14	8.93E-1	1.07E-1	9.79E-1	2.13E-2	2.33E-2	8.50E-2	3.61E-2	1.33E-1
15	8.96E-1	1.05E-1	9.79E-1	2.08E-2	2.37E-2	8.46E-2	3.69E-2	1.33E-1
16	8.98E-1	1.03E-1	9.80E-1	2.04E-2	2.43E-2	8.43E-2	3.77E-2	1.32E-1
17	9.00E-1	1.00E-1	9.80E-1	2.00E-2	2.49E-2	8.39E-2	3.85E-2	1.32E-1
18	9.02E-1	9.86E-2	9.80E-1	1.97E-2	2.52E-2	8.36E-2	3.92E-2	1.31E-1
19	9.04E-1	9.68E-2	9.80E-1	1.93E-2	2.58E-2	8.32E-2	3.99E-2	1.31E-1
20	9.05E-1	9.52E-2	9.81E-1	1.89E-2	2.62E-2	8.29E-2	4.06E-2	1.30E-1
21	9.07E-1	9.37E-2	9.81E-1	1.86E-2	2.66E-2	8.26E-2	4.13E-2	1.29E-1
22	9.08E-1	9.23E-2	9.82E-1	1.84E-2	2.70E-2	8.22E-2	4.19E-2	1.29E-1
23	9.10E-1	9.09E-2	9.82E-1	1.82E-2	2.74E-2	8.20E-2	4.26E-2	1.28E-1
24	9.11E-1	8.97E-2	9.82E-1	1.79E-2	2.78E-2	8.16E-2	4.32E-2	1.27E-1
25	9.12E-1	84.8E-2	9.82E-1	1.76E-2	2.82E-2	8.13E-2	4.38E-2	1.27E-1

Also graphically depicted data according to thyroid size from 1 to 25ml separately for gamma and beta rays are presented in figures (1 & 2).

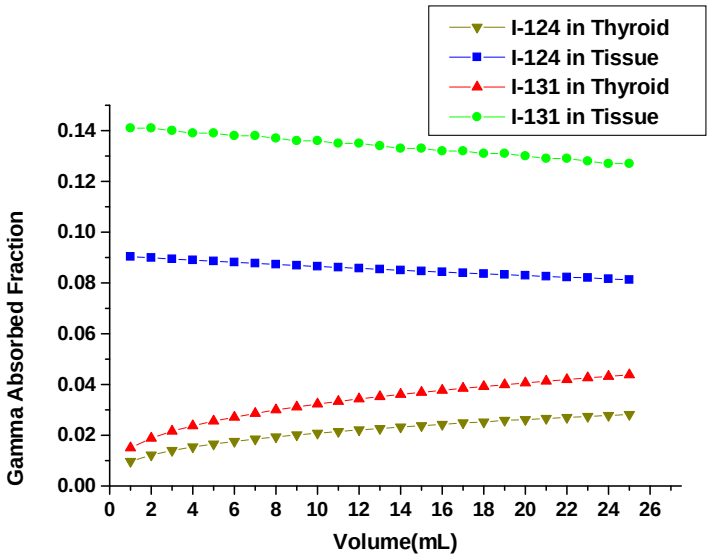

Figure (1): Comparsion Gamma Absorbed Fraction I-124 and I-131

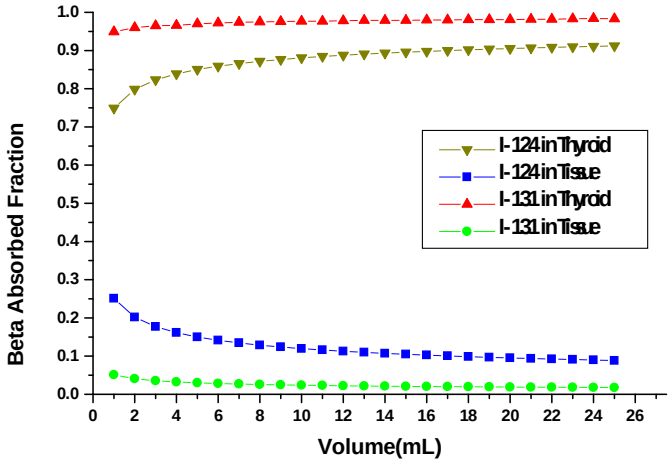

Figure (2): Comparsion Beta Absorbed Fraction I-124 and I-131

Beta rays are responsible for therapeutics effects of radioactive iodine. More amounts of absorbed fraction through thyroid gland are needed for more destruction and optimal effect on cancerous or hyper functioning cells. I-124 and I-131 beta absorbed fraction are different. I-124 has less absorption in thyroid as target organ than I-131. This difference is more prominent in small volumes of thyroid, but in larger thyroids I-124 absorbed fraction is closing to I-131(Table 2). For better comparison, ratio of I-124 and absorbed fractions to I-131 ($\varphi_{124}/\varphi_{131}$) is calculated for these two organ regarding to difference volumes of thyroid gland and shown in table (2).

Table (2): Ratio Absorbed Fraction I-124 to I-131

$\varphi_{124}/\varphi_{131}$ For 25mL thyroid		$\varphi_{124}/\varphi_{131}$ For 1mL thyroid		Organ
Beta	**Gamma**	**Beta**	**Gamma**	
0.928	**0.643**	**0.789**	**0.646**	**Thyroid**
5.022	**0.640**	**4.921**	**0.641**	**Tissue**

As seen in described table(2),beta absorbed fraction for I-124 in a thyroid 1mL volume is 20% less than for I- 131 and for a thyroid whit 25mL volume is 7% less than for I- 131. A normal thyroid gland in an adult is about 25mL in volume and in most of hyper functioning glands or surgically unrespectable functioning thyroid tumoural masses or metastases increase in size considerably is noted therefore it is expected that I-124 effect is similar to I-131 in hyper functioning goiter and tumoural mass and can be consider as a substitute. Absorbed fraction in other soft tissues around thyroid and other parts of the body should be at least to minimizing side effects. Figure (2) shows similar results for I-131 and I-124 in larger thyroid Volumes. Gamma rays which are used in imaging by gamma cameras have a less absorbed fraction for I-124 than I- 131in soft tissue which is a benefit for I-124(fewer side effects).

Conclusion

Our study suggests that I-124 isotope can be used as replacement forI-131in thyroid treatments especially with similar effects in large hyper function thyroid glands or large tumoural thyroid masses. Comparison of I-124 and I-131 absorbed fraction in large thyroids (more than 25mL by this study) is recommended.

REFERENCES

Allah Abadia A, Daykin J, Sheppard MC, Gough CSCL, Franklyn JA.2001. Radiological treatment of hyperthyroidism-progonostic factors for outcome. The Journal of Clinical Endocrinology & Metabolism, 86(3): 3611-3617.

Cooper DS, Doherty GM, Haugen BR, Kloos RT.2006. Management guidelines for patients with thyroid nodules and differentiated thyroid cancer. THYROID, 16(2): 109-141.

Cember H, Johnson TE.2009. Introduction to health physics, 4th Edition, McGraw-Hill, New York.

Firestone RB, Ekström LP.1999. LBNL Isotopes Project - LUNDS Universitet WWW Table of Radioactive Isotopes. Version 2.1,. The website: http://ie.lbl.gov/toi/nuclide.asp?iZA=530131.

Snyder W, Ford M, Warner G.1969. Estimates of absorbed fractions for monoenergetic photon sources

uniformly distributed in various organs of a heterogeneous phantom: MIRD pamphlet no. 5. *J Nucl Med* 10 (suppl 3):5–52.

Traino AC, di Martino F, Lazzeri M,. Stabin MG.2000. Influence of thyroid volume reduction on calculated dose in radioiodine therapy of Graves' hyperthyroidism. *Phys Med Biol* 45: 121–129.

Vini L, Harmer C.2000. Radioiodine treatment for differentiated thyroid cancer. Clin Oncl (Rcoll Radiol), 12(6): 365-72.

Waters L S.2002. "MCNPX User's Manual, version 2.3.0", LA-UR-02-2607, Los Alamos, NM, USA.